**Chapter 9**

**Hypothesis Testing**

**Case Problem 1: Quality Associates, Inc.**

1. The hypothesis testing results are shown below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sample 1** | **Sample 2** | **Sample 3** | **Sample 4** |
| **Sample Size** | 30 | 30 | 30 | 30 |
| **Mean** | 11.959 | 12.029 | 11.889 | 12.081 |
| **Standard Deviation** | 0.220 | 0.220 | 0.207 | 0.206 |
|  |  |  |  |  |
| **Level of Significance (alpha)** | 0.010 | 0.010 | 0.010 | 0.010 |
| **Critical Value (lower tail)** | -2.576 | -2.576 | -2.576 | -2.576 |
| **Critical Value (upper tail)** | 2.576 | 2.576 | 2.576 | 2.576 |
|  |  |  |  |  |
| **Hypothesized value** | 12 | 12 | 12 | 12 |
| **Standard Error** | 0.040 | 0.040 | 0.038 | 0.038 |
| **Test Statistic** | -1.027 | 0.713 | -2.935 | 2.161 |
| ***p*-value** | 0.304 | 0.476 | 0.003 | 0.031 |

Only sample 3 leads to the rejection of the hypothesis *H*0: *µ* = 12. Thus, corrective action is warranted for sample 3. The other samples indicate *H*0 cannot be rejected and thus from all we can tell, the process is operating satisfactorily. Sample 3 with  = 11.89 shows the process is operating below the desired mean. Sample 4 with  = 12.08 is on the high side, but the *p*-value of .03 is not sufficient to reject *H*0.

2. The sample standard deviations for all four samples are in the .20 to .22 range. It appears that the process population standard deviation assumption of .21 is good.

3. With  = .01, *z*.005 = 2.576. Using the standard error of the mean =0.0383, the upper and lower control limits are computed as follows:

Upper Control Limit = 12 + 2.576 (0.0383) = 12.0987

Lower Control Limit = 12 - 2.576 (0.0383) = 11.9013

As long as a sample mean  is between these two limits, the process is in control and no corrective action is required. Note that sample 3 with a mean of 11.89 shows corrective action is necessary because the sample mean is outside the control limits.

4. Increasing the level of significance will cause the null hypothesis to be rejected more often. While this may mean quicker corrective action when the process is out of control, it also means that there will be a higher error probability of stopping the process and attempting corrective action when the process is operating satisfactorily. This would be an increase in the probability of a making a Type I error.

## Case Problem 2: Ethical Behavior of Business Students at Bayview University

1. The following questions were used to obtain data regarding three types of cheating:

During your time at Bayview, did you ever present work copied off the internet as your own?

During your time at Bayview, did you ever copy answers off another student’s exam?

During your time at Bayview, did you ever collaborate with other students on projects that were supposed to be completed individually?

Using the data provided we can compute the proportion of all students, male students, and female students that presented work copied off the internet as their own, copied answers off another student’s exam, or collaborated with other students on projects that were supposed to be completed individually.

But, to estimate the percentage of students that have engaged in some form of cheating, we need to count how many students answered yes to one or more of the above questions. One of the easiest ways is to do this is to add another column to the data set whose cell values will be “No” if the student answered no to each of the above questions and “Yes” if the student answered yes to one or more of the questions. There are a number of ways to obtain the values in this new column. One of the simplest methods is to just sort the original data so the No responses for each of the three questions will appear at the beginning of the data set; then it is a simple matter to enter and paste No and Yes values into the corresponding cells in the new column. And, since we need to obtain counts for both male and female students, the data can also be sorted according to Gender. We will assume that this preliminary work has been done and that the new column is labeled “Cheated.”

The following tables show the number and percentage of students that answered No and Yes to each survey question, as well as the number of No and Yes values in the column named Cheated.

**All Business Students**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Copied  from Internet | Count | Percent | Copied  on Exam | Count | Percent |
| No | 74 | 82.22 | No | 72 | 80.00 |
| Yes | 16 | 17.78 | Yes | 18 | 20.00 |
| N | 90 |  | N | 90 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Collaborated on Individual Project | Count | Percent | Cheated | Count | Percent |
| No | 61 | 67.78 | No | 53 | 58.89 |
| Yes | 29 | 32.22 | Yes | 37 | 41.11 |
| N | 90 |  | N | 90 |  |

These results show that 16 of the 90 business students (17.78%) presented work copied off the internet as their own; 18 of the 90 students (20%) copied answers off another student’s exam; and 29 of the 90 (32.22%) collaborated with other students on projects that were supposed to be completed individually. Overall, 37 of the 90 students (41.11%) were involved in some type of cheating.

**Male Students**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Copied  from Internet | Count | Percent | Copied  on Exam | Count | Percent |
| No | 41 | 85.42 | No | 39 | 81.25 |
| Yes | 7 | 14.58 | Yes | 9 | 18.75 |
| N | 48 |  | N | 48 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Collaborated on Individual Project | Count | Percent | Cheated | Count | Percent |
| No | 30 | 62.50 | No | 27 | 56.25 |
| Yes | 18 | 37.50 | Yes | 21 | 43.75 |
| N | 48 |  | N | 48 |  |

For the 48 male students, 14.58% presented work copied off the internet as their own; 18.75% copied answers off another student’s exam; and 37.50% collaborated with other students on projects that were supposed to be completed individually. Overall, 21 of the 48 male students, or 43.75%, were involved in some type of cheating.

**Female Students**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Copied  from Internet | Count | Percent | Copied  on Exam | Count | Percent |
| No | 33 | 78.57 | No | 33 | 78.57 |
| Yes | 9 | 21.43 | Yes | 9 | 21.43 |
| N | 42 |  | N | 42 |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Collaborated on Individual Project | Count | Percent | Cheated | Count | Percent |
| No | 31 | 73.81 | No | 26 | 61.90 |
| Yes | 11 | 26.19 | Yes | 16 | 38.10 |
| N | 42 |  | N | 42 |  |

For the 42 female students, 21.43% presented work copied off the internet as their own; 21.43% copied answers off another student’s exam; and 26.19% collaborated with other students on projects that were supposed to be completed individually. Overall, 16 of the 42 female students, or 38.10%, were involved in some form of cheating.

**Additional Comments**

* The proportion of students involved in some type of cheating is higher for male students (.4375) than for female students (.3810).
* The most common form of cheating involved collaborating on projects that were supposed to be completed individually; approximately 32% of all business students were involved in this type of cheating.
* The proportion students that presented work copied off the internet as their own is higher for female students (.2143) than for male students (.1458).

2. 95% confidence intervals for the proportion of students that were involved in some type of cheating follow.

**All Business Students**

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Margin of error = 

95% Confidence interval: .4111.1017 or .3094 to .5128

**Male Students**



Margin of error = 

95% Confidence interval: .4375.1403 or .2972 to .5778

**Female Students**



Margin of error = 

95% Confidence interval: .3810.1469 or .2341 to .5279

3. The *Chronicle of Higher Education* reported that the proportion of business students who admitted to some form of cheating was .56. Since we are interested in testing to see if the population proportion of business students at Bayview who admitted to some form of cheating is less than business students at other universities, we are looking for evidence that *p*, the population proportion, is less than .56. Thus, the appropriate hypothesis test is



We will use α = .05.

 and 



Since the test statistic is in the lower tail, the *p*-value is the area under the curve for *z* -2.85.

Using the standard normal probability table, the *p*-value = .0022

Because the *p*-value = .0022 .05 we reject and conclude that the ethical behavior of students at Bayview University (with respect to cheating) is better than for business schools at other universities.

4. The *Chronicle of Higher Education* reported that the proportion of non-business students who admitted to some form of cheating was .47. Since we are interested in testing to see if the population proportion of business students at Bayview who admitted to some form of cheating is less than non-business students at other universities, we are looking for evidence that *p*, the population proportion, is less than .47. Thus, the appropriate hypothesis test is



We will use α = .05.

and 



Since the test statistic is in the lower tail, the *p*-value is the area under the curve for *z* -1.12.

Using the standard normal probability table, the *p*-value = .1314

Because the *p*-value = .1314 > .05 we cannot reject.

There is not sufficient evidence to conclude that the ethical behavior of students at Bayview University (with respect to cheating) is better than for non-business students at other universities.

5. The good news is that the proportion of all business students at Bayview that are involved in some type of cheating is much less than the proportion for business students at other universities. Nonetheless, the fact that approximately 41% of all Bayview business students are involved in some type of cheating still indicates a serious problem for the college. The dean needs to take additional steps to deal with the problem of cheating in the college. Possible steps the dean might consider include the following:

* Form a committee of students and faculty to investigate how students and faculty can work together to reduce the extent of cheating.
* Require course outlines to include a statement regarding the expectations of the instructor regarding cheating incidents and how they will be dealt with.
* Sponsor seminars where business executives can talk about the importance of ethical behavior.
* Continue to administer the exit survey so data can be obtained to determine if efforts to reduce cheating are working.